VARIATIONS IN THE APPEARANCE OF HUMAN ELASTIC CARTILAGE[1]

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ABSTRACT

Cartilage from the external ear, epiglottis, and auditory tube from 22 adult human cadavers, ranging in age from 52 to 64 years, and from seven newborn infants was examined microscopically to ascertain any morphological differences in structure. All cartilages from the newborn infants were hyaline, showing evenly dispersed chondrocytes and lack of elastic fibers, with the exception of the epiglottic cartilage, which possessed a few such fibers at this stage. In adult cartilages, the presence or absence and location of young growing, mature, and/or calcified chondrocytes is described. All cartilages had a PAS-positive matrix. The distribution of elastic fibers is defined. The differences in adult human cartilages are summarized and lead us to suggest the term *elastoid* as the name for the cartilage of the auditory tube.

INTRODUCTION

Elastic cartilage occurs in only a few places in the human body: (1) external ear, (2) epiglottis, (3) auditory tube, and (4) some laryngeal and bronchiolar cartilages (Bailey, 1964; Bloom and Fawcett, 1968). Investigators (Urbants-

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chitsch, 1884; Citelli, 1905; Bryant, 1907; Graves and Edwards, 1944) have presented varying opinions as to the microscopic appearance and structure of the hook of cartilage associated with the auditory tube. Urbantschitsch (1884) believed that the tubal cartilage changed with age: in children it was hyaline with an even distribution of chondrocytes; in contrast, in adults the chondrocytes were grouped into island-like clusters surrounded by elastic fibers. Citelli (1905) confirmed the even distribution of chondrocytes in children, but claimed that the ground substance was highly impregnated with a network of elastic fibers. Windle (1960) specified that one of the earliest signs of aging in hyaline cartilage was its gradual transformation to a fibrous type with elastic-like fibers. Graves and Edwards (1944) stated that the adult tubal cartilage consists of groups of chrondrocytes surrounded by a fibrous-appearing ground substance containing occasional calcified cartilage cells. Citelli (1905) also noted some calcified chondrocytes in adult preparations of elastic cartilage. Clark (1965) maintained that elastic cartilage normally shows less tendency to calcify with age than does hyaline.

As a result of a previous study (Welch, 1963) of the auditory tube in some mammals, including man, the unique appearance of the tubal cartilage in the latter was noted. The purpose of the present investigation was to examine human elastic cartilage histologically, to determine its true morphological structure.

MATERIALS AND METHODS

Representative specimens of cartilage from the: (1) auditory tube, (2) external ear, and (3) epiglottis were removed from 22 adult human cadavers, ranging in age from 52 to 64 years, and from seven newborn infants. Each specimen was fixed in 10% neutral formalin and double embedded in paraffin (Cowdry, 1952). Material from cadavers was cut at 4 μ, and stained with hematoxylin and eosin, azan (Gurr, 1962), Movat's pentachrome (Movat, 1955), the Alcian blue-periodic acid-Schiff method (AB/PAS) (Mowry, 1956), and treated with the von Kossa stain for bone mineral (Cowdry, 1952). Material from the newborn infants was cut at 10 μ and stained with hematoxylin and eosin, and azan (Gurr, 1962).

OBSERVATIONS

Adult Cartilage

External ear.—The cartilage is surrounded by a thin perichondrium, with young proliferating cartilage cells oriented parallel to the inner surface of this membrane (fig. 1). In the cartilage, chondrocytes, one per lacuna, are arranged in rows, separated by elastic fibers (fig. 1), and lie at right angles to the perichondrium; cell nests are infrequent. The elastic fibers are confined between the rows of chondrocytes and appear either (1) to be attached directly to the perichondrium, or (2) to intermingle with the young chondrocytes on the inner aspect of the perichondrium. The intercellular substance is slightly PAS-positive, and occasional scattered calcified chondrocytes are observed (fig. 5).

Epiglottic.—The perichondrium (fig. 2, insert) is thin and devoid of intermingling elastic fibers, with young chondrocytes near its inner surface. The chondrocytes in the middle of the cartilage are scattered, or in isogenous groups of two cells, with cell nests being a regular feature; no consistency in cell arrangement exists (fig. 2). The slightly PAS-positive intercellular substance contains numerous branching and anastomosing networks of elastic fibers (fig. 2), which become more dense at the midpoint of the cartilage. Calcified chondrocytes (fig. 6) are sufficiently abundant to suggest degenerative changes.

Auditory Tube.—The thin perichondrium (fig. 3) which surrounds the tubal cartilage lacks chondrocytes adjacent to its inner surface. Medically the chrondrocytes are arranged in island-like clusters (fig. 4) composed of one cell per lacuna; elastic fibers (fig. 4) appear to radiate from these clusters and gradually disperse as they pass distad. Plentiful clefts traversing the cartilage contain vessels,

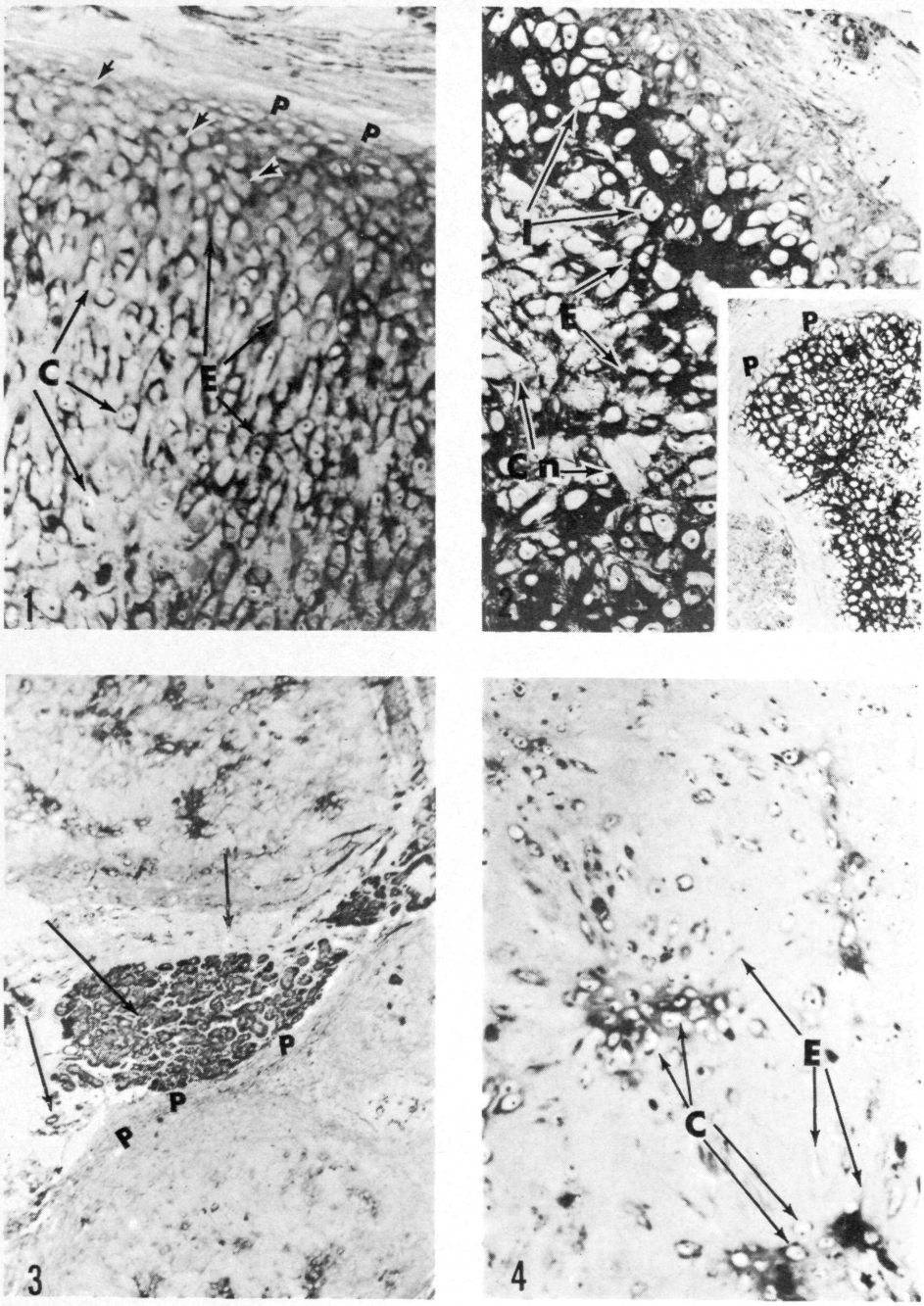
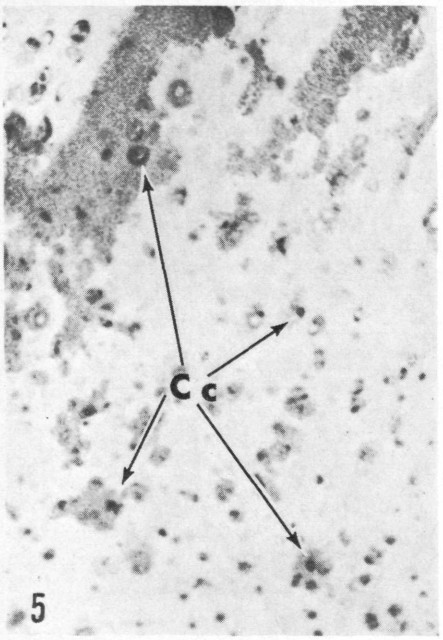


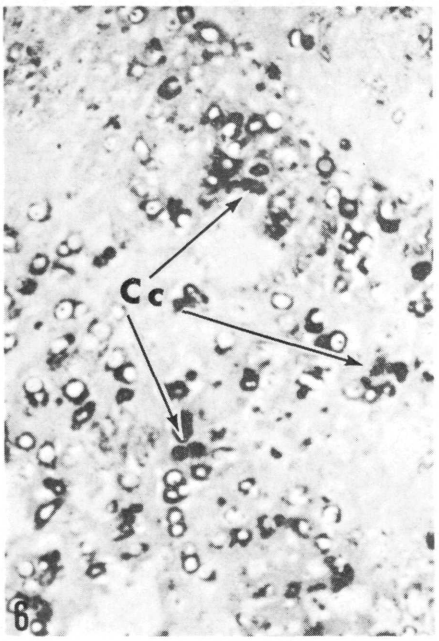
FIGURE 1. Adult external ear cartilage. Young chondrocytes (arrowheads), chondrocytes (C), elastic fibers (E), and perichondrium (P). Pentachrome, ×100.

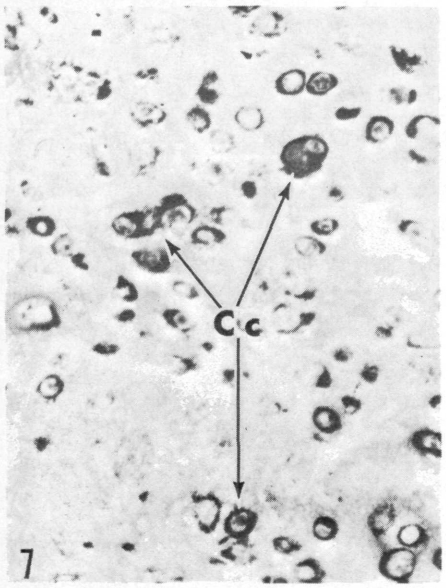
FIGURE 2. Adult epiglottic cartilage. Perichondrium (insert, P), cell nests (Cn), elastic fibers (E), and isogenous groups of two chondrocytes (I). Pentachrome, ×40 (insert), ×100.

FIGURE 3. Adult auditory tube cartilage (elastoid). Vessels, glands, and connective tissue within the cartilage clefts (arrows), perichondrium (P). Pentachrome, ×40.

FIGURE 4. Adult auditory tube cartilage (elastoid). Chondrocytes (C), and elastic fibers (E). Pentachrome, ×100.







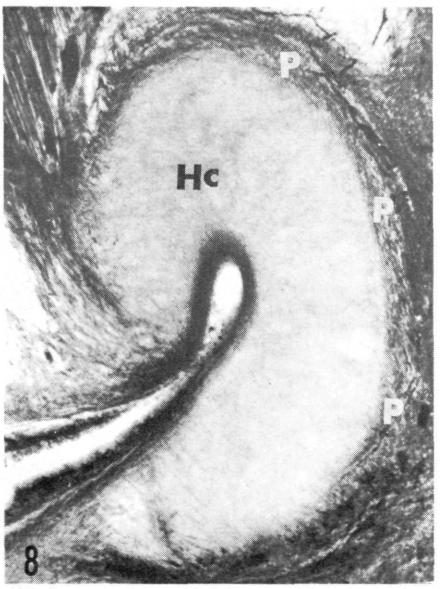


FIGURE 5. Calcified chondrocytes (Cc) of the adult external ear cartilage. von Kossa, ×100.
FIGURE 6. Calcified chondrocytes (Cc) of the adult epiglottic cartilage. von Kossa, ×100.
FIGURE 7. Calcified chondrocytes (Cc) of the adult auditory tube cartilage (elastoid). von Kossa, ×100.
FIGURE 8. An example of hyaline cartilage (Hc) in the newborn infant. External ear cartilage with surrounding perichondrium (P). Azan, ×40.

glands, and/or loose connective tissue (fig. 3). The smooth intercellular matrix is slightly PAS-positive, and numerous calcified chondrocytes (fig. 7), suggesting degenerative changes, are present.

Newborn Cartilage

All cartilages are hyaline and surrounded by a thick loosely-arranged fibrous perichondrium (fig. 8). The chondrocytes are evenly dispersed throughout the clear glassy-appearing intercellular matrix, which is devoid of elastic fibers, in all but the epiglottic cartilage, which at this stage shows a few delicate elastic fibers.

DISCUSSION

The cartilage of the external ear, epiglottis, and auditory tube of adult man each shows a distinct pattern which is summarized in table 1. Previous investigators (Urbantschitsch, 1884; Citelli, 1905; Bryant, 1907; Graves and Edwards, 1944), however, have mainly stressed morphological differences in the cartilage

TABLE I

A comparison of elastic cartilage in adult man

	Specimen	Perichondrium	Young chondrocytes near inner surface of perichondrium	Mature Chondrocytes	Elastic Fibers	PAS positive matrix	Calcified Chondrocytes
1	External ear	Thin	+, Parallel to perichondrium with intermingling thin elastic fibers	At right angles to perichondrium; one cell/lacuna	Confined to matrix between rows of chondrocytes	+	+
2	Epiglottic	Thin	+, Parallel to perichondrium; elastic fibers not present	Scattered or in isogenous groups; cell nests a regular feature	Dense network which conceals matrix	+	++
3	Auditory Tube	Thin	−	Island-like clusters; one cell/lacuna	Radiate from clusters of chondrocytes	+	+

\+ =present.
++=present and increased.
− =absent.

of the auditory tube. In the auditory tube of the adult, the slightly PAS-positive intercellular material varies according to the arrangement of elastic fibers (fig. 4). The term *elastoid* is proposed for this cartilage, because of the scarcity and restricted distribution of elastic fibers and because of the arrangement of single chondrocytes in island-like clusters.

Calcified chondrocytes are found in each adult cartilage, being most abundant in the epiglottis. These cells might be indicative of degenerative changes associated with aging, although Clark (1965) maintains that elastic cartilage shows less tendency toward calcification than does hyaline.

In the newborn infant, the exemplary cartilages exhibit a thick, loosely arranged perichondrium surrounding evenly distributed chondrocytes. Citelli (1905) claimed a network of elastic fibers within the ground substance of the auditory tube cartilage in the neonate. In contrast, the present study reveals elastic fibers only in the epiglottic cartilage of the newborn infant.

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